New „face” of the Borowiec Satellite Laser Ranging Station

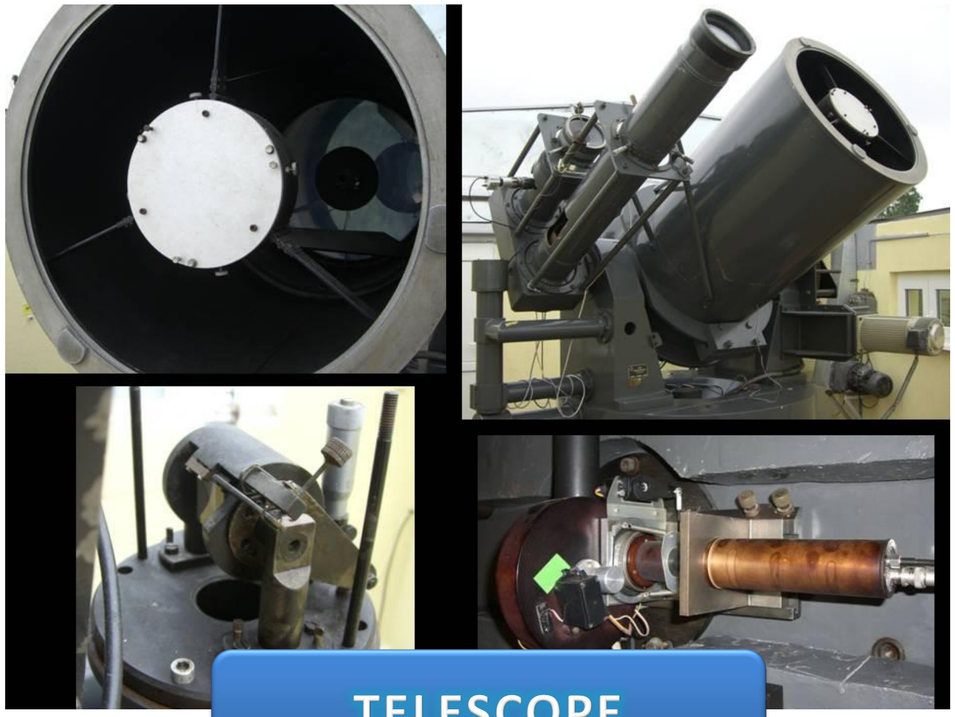
Paweł Lejba, Tomasz Suchodolski, Stanisław Schillak,
Jacek Bartoszak, Piotr Michałek, Stanisław Zapaśnik

Space Research Center PAS

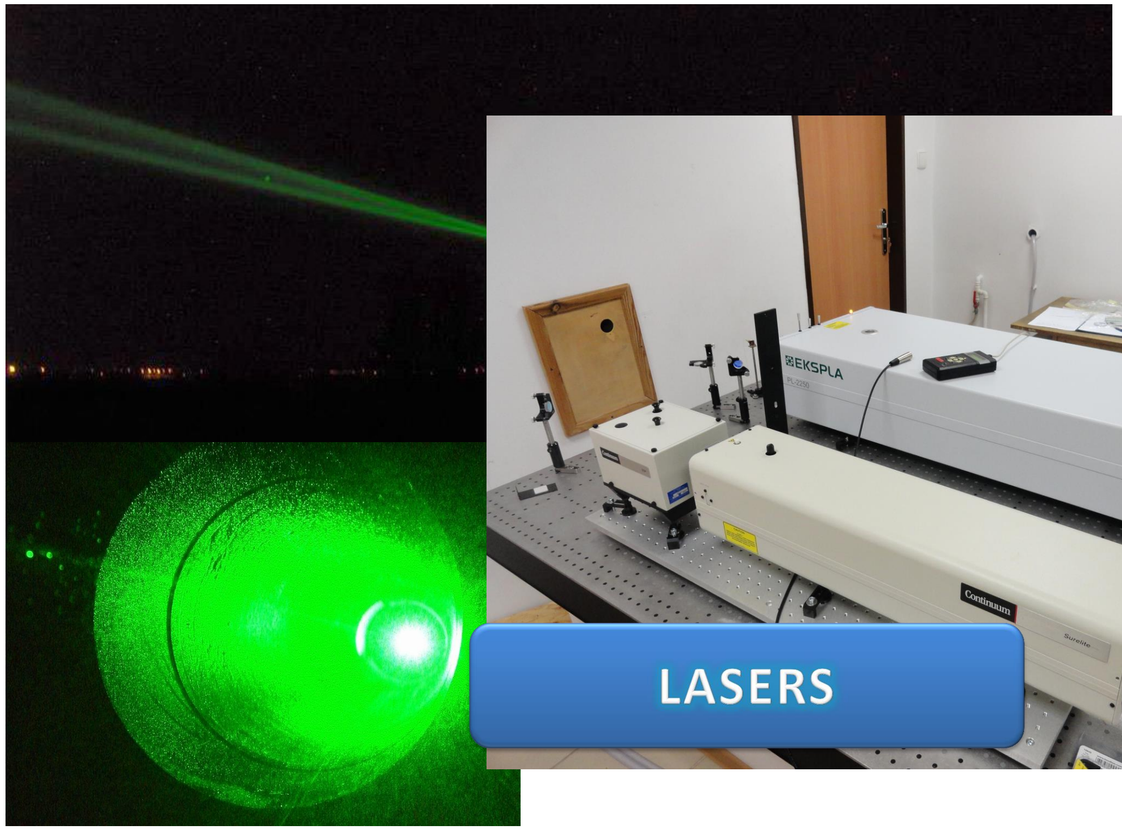
20th International Workshop on Laser Ranging, Potsdam Germany, October 11, 2016

SRC Borowiec SLR

BUILDING



TELESCOPE



LASERS

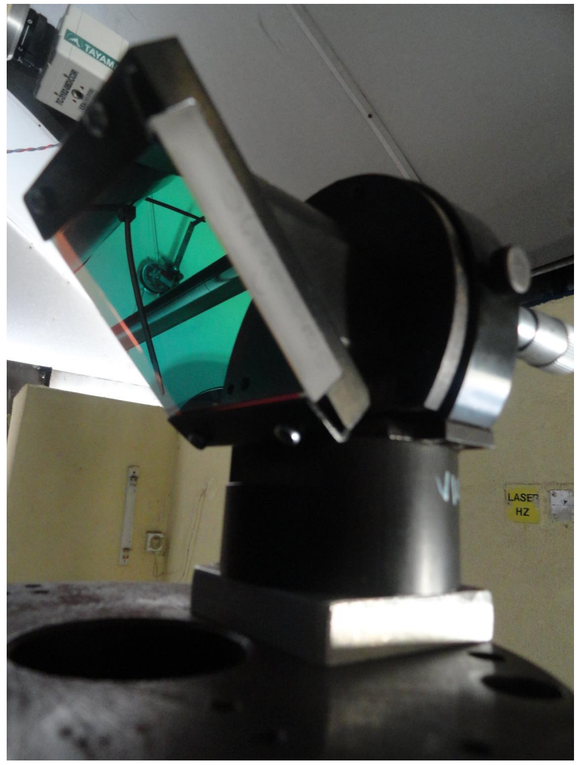
OPERATOR ROOM

Laser station modernization

Optics exchange

Primary and secondary mirrors

dielectric mirrors coude path

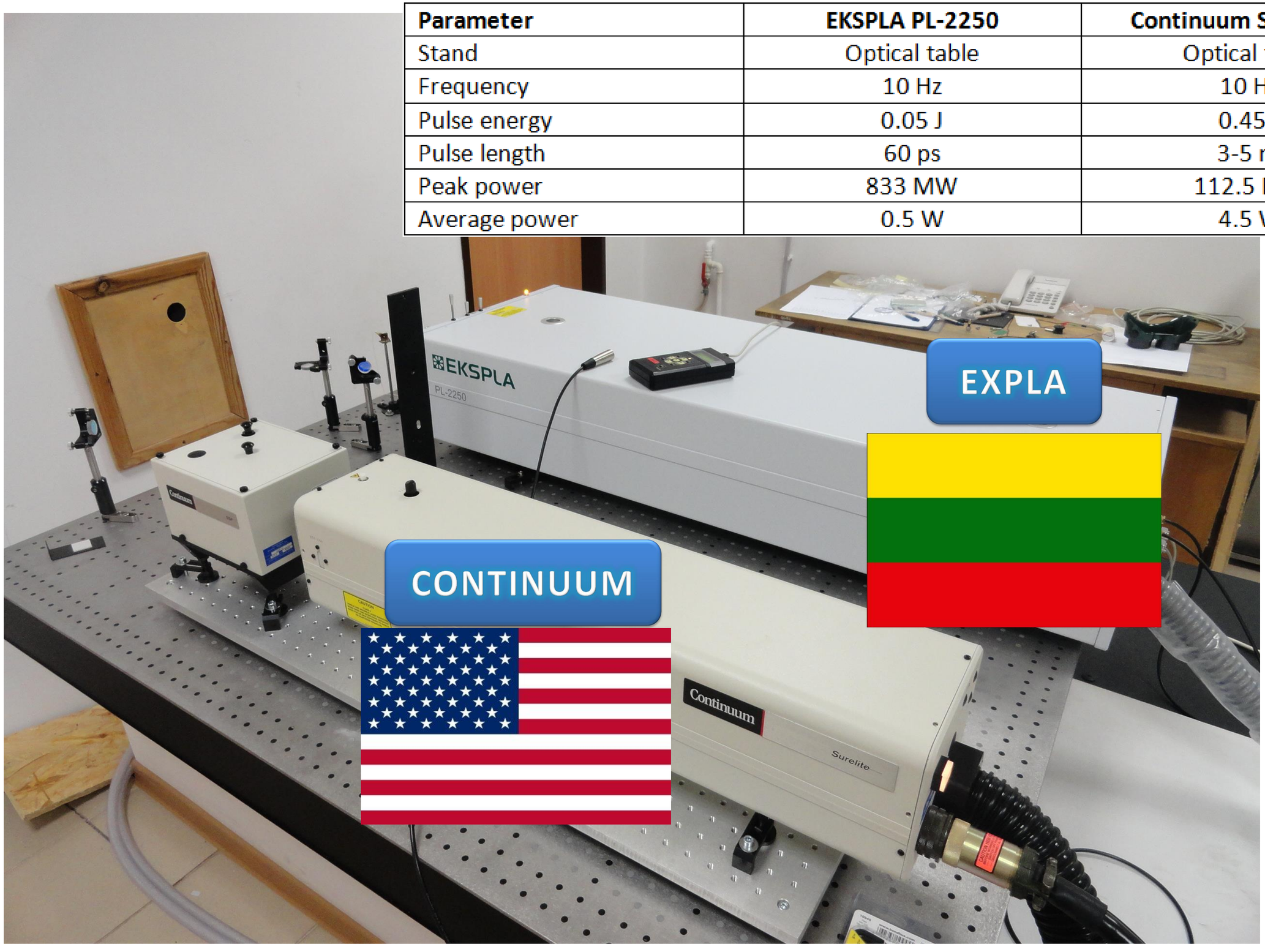


Telescope mount

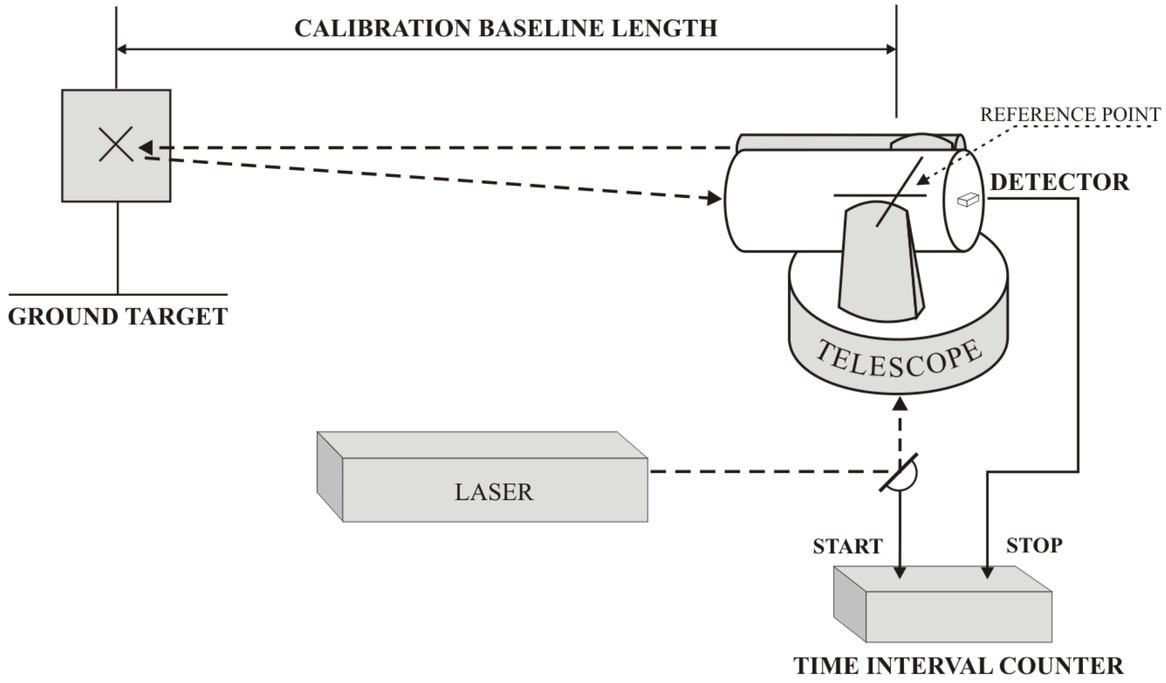
Mount	Azimuth – Elevation
Tracking	Step by step
Encoder resolution	1.8 arsec
Receiver	Cassegrain system
Diameter of the main mirror	65 cm
Diameter of the secondary mirror	20 cm
FOV	5 arcmin
Guide telescope	Maksutov system
Tracking	Visual (CCD camera)
Diameter of the mirror	20 cm
FOV	1^0

New laser modules

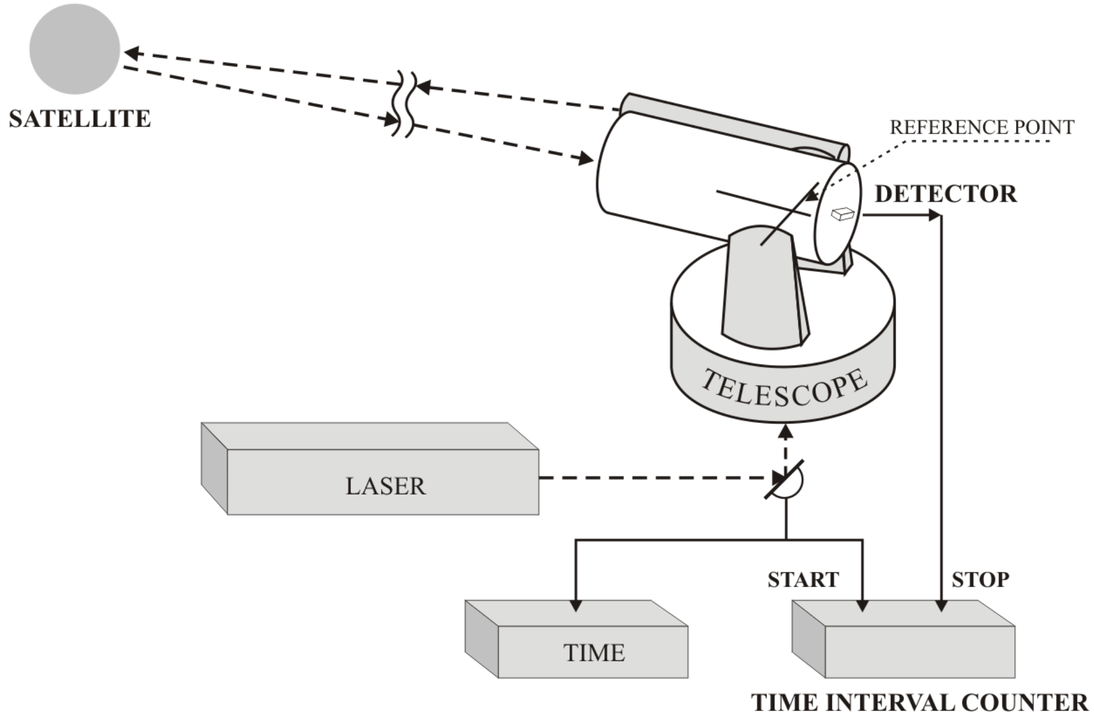
Parameter	EKSPLA PL-2250	Continuum Surelite III
Stand	Optical table	Optical table
Frequency	10 Hz	10 Hz
Pulse energy	0.05 J	0.45 J
Pulse length	60 ps	3-5 ns
Peak power	833 MW	112.5 MW
Average power	0.5 W	4.5 W



SRC Borowiec SLR

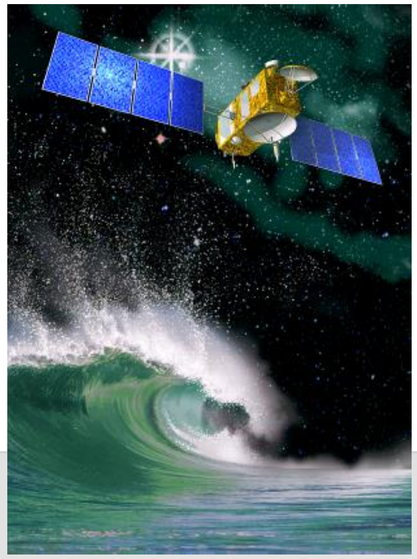


CALIBRATION MODE



OPERATION MODE

Time axis – last 2 years



2014
Station modernization

March 2, 2015
First returns from JASON-2

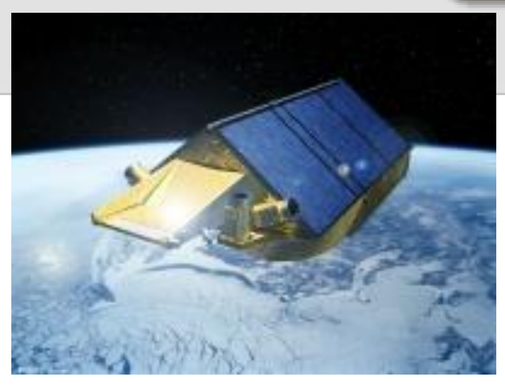
May 6, 2015
First good pass of CRYOSAT-2

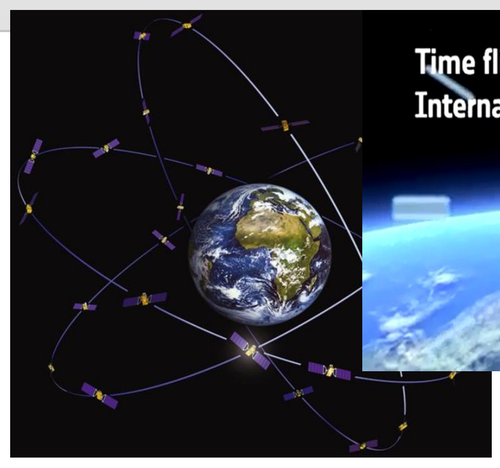
July 10, 2015
START the quarantine
First good pass of LAGEOS2

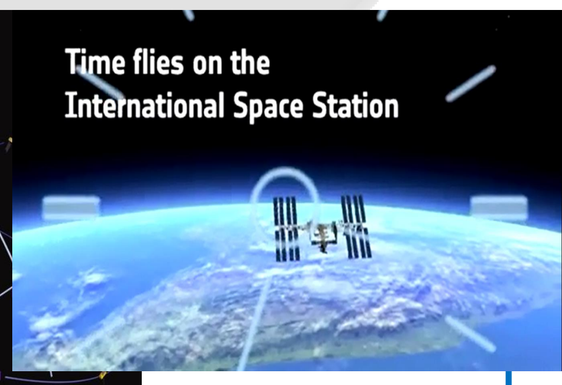
December 31, 2015
Quarantine status
6 passes of LAGEOS1
41 passes of LAGEOS2
47 passes of LARES

August 2016
Laser observations of space debris
Laser observations of GNSS satellites

NEAR FUTURE
Second laser system
Timing experiments (T2L2 and ACES/ELT)
Laser observations at day





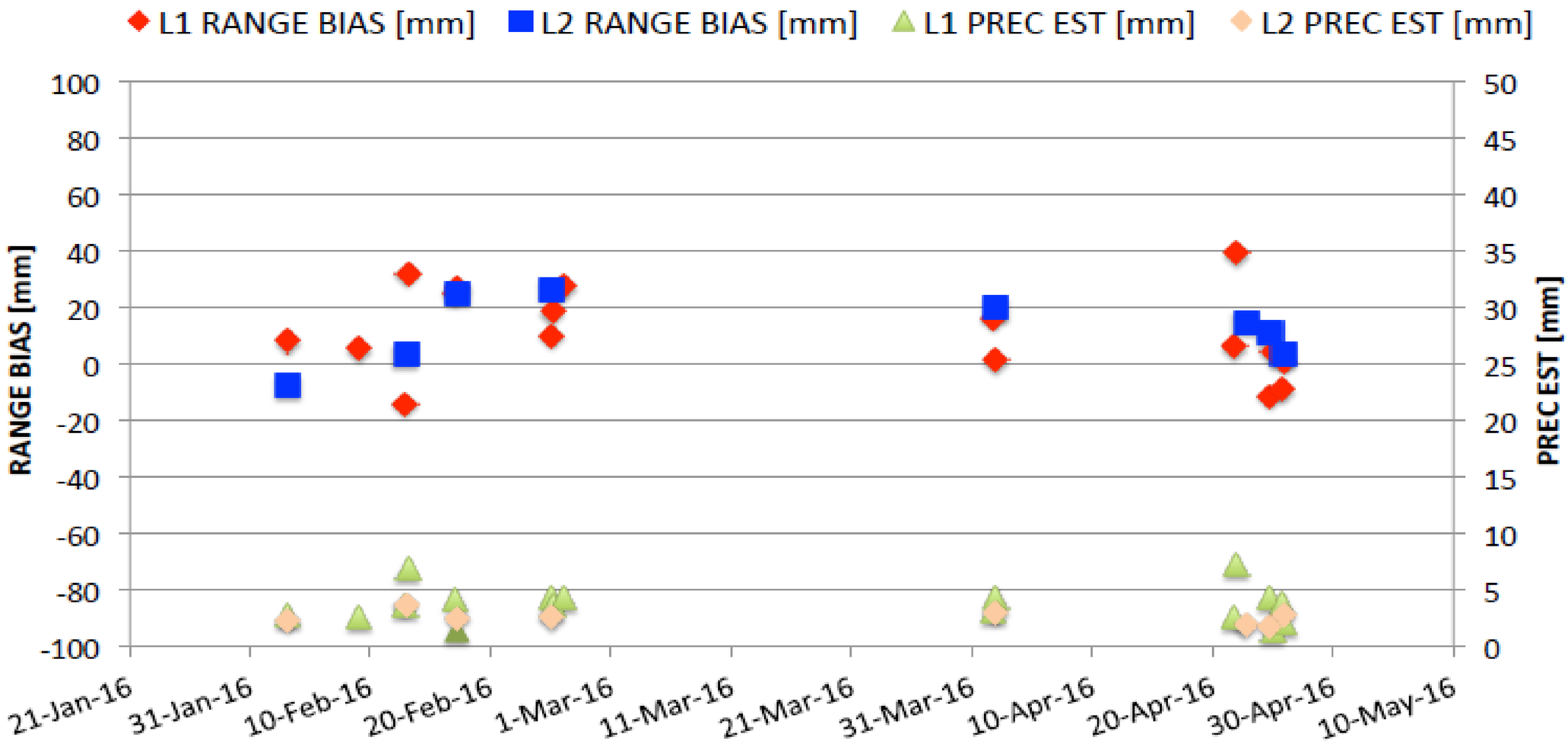


Quarantine – April 26, 2016

LAGEOS 1 & LAGEOS 2

L1 78113802	PREC EST [mm]	RANGE BIAS [mm]
Mean	3.7	11.0
STD	1.6	15.6
RMS	4.0	18.7
Point	17	17

L2 78113802	PREC EST [mm]	RANGE BIAS [mm]
Mean	2.6	12.0
STD	0.6	11.9
RMS	2.6	16.3
Point	8	8



ILRS bias report – October 7, 2016

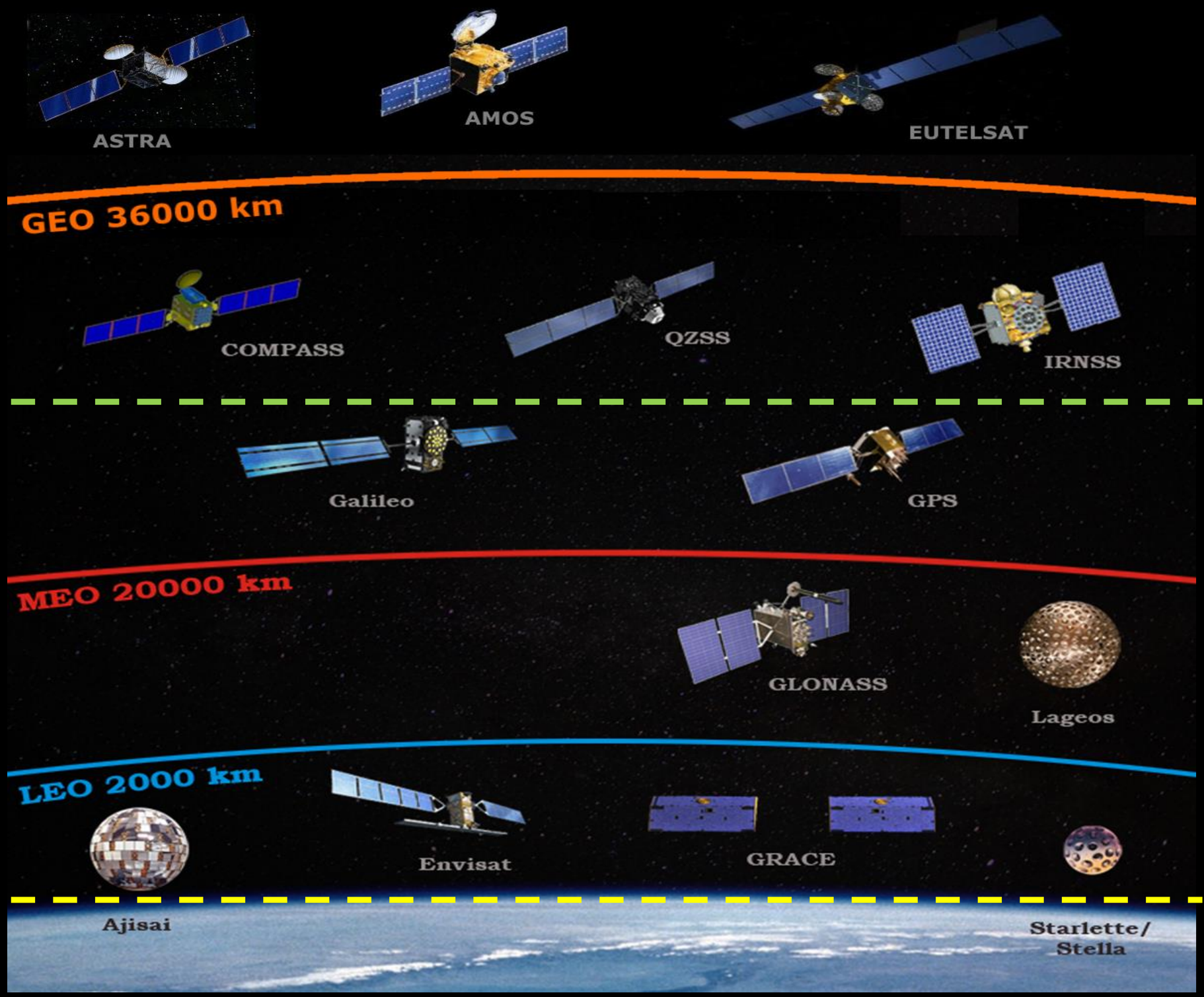
ILRS Combined Range Bias Report 1
****

2016-09-27 00:00 UT - 2016-10-07 00:00 UT

Compiled by: SLR Observatory Zimmerwald
Date : 2016-10-07 12:30 UT
E-Mail : martin.ploner@aiub.unibe.ch

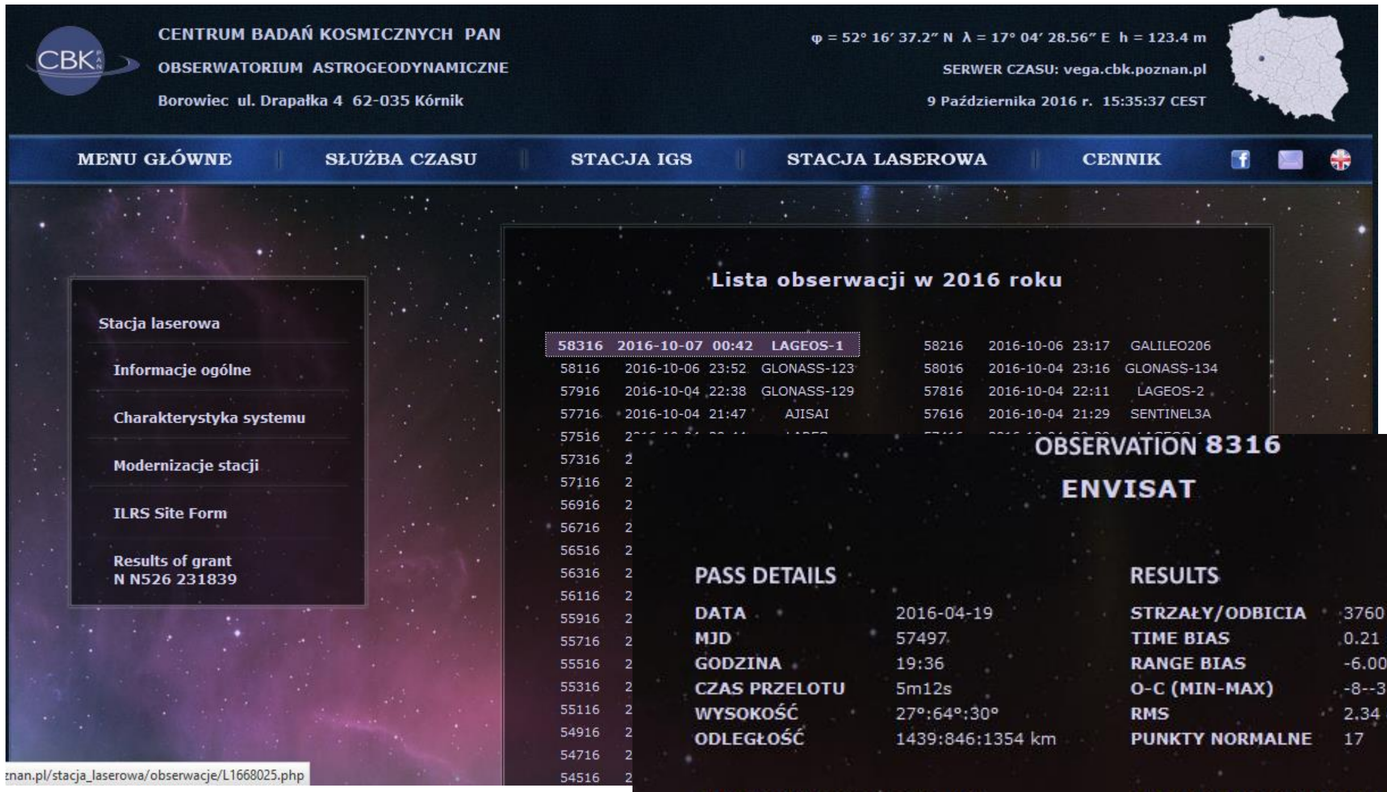
7811 BORL Borowiec				DGFI		MCC		HIT-U		SAO		JCET	
		sat	wl	rb	pr	rb	pr	rb	pr	rb	pr	rb	pr
7811	2016-09-27 00:13	LAG1	532	-7	5	-1	5	-4	4			-1	5
7811	2016-09-27 01:20	LAG2	532	4	3	8	3	6	3			4	3
7811	2016-09-27 19:36	LAG1	532	14	4	5	4	-2	4			8	4
7811	2016-09-27 22:51	LAG1	532	-6	4	-8	4	-10	3			-4	4
7811	2016-09-27 23:27	LAG2	532	-5	5	-1	4	-1	4			6	4
7811	2016-09-29 23:36	LAG2	532	0	6	1	6	-8	5			7	6
7811	2016-09-29 23:53	LAG1	532	-15	4	-10	4	-7	3				
7811	2016-09-29 23:54	LAG1	0									*	*
7811	2016-10-04 20:31	LAG1	532	2	8	1	3	-3	7			23	7
7811	2016-10-04 22:16	LAG2	532	9	4	6	4	-10	4			-8	4
7811	Average		532	0	4	0	4	-4	4			4	4

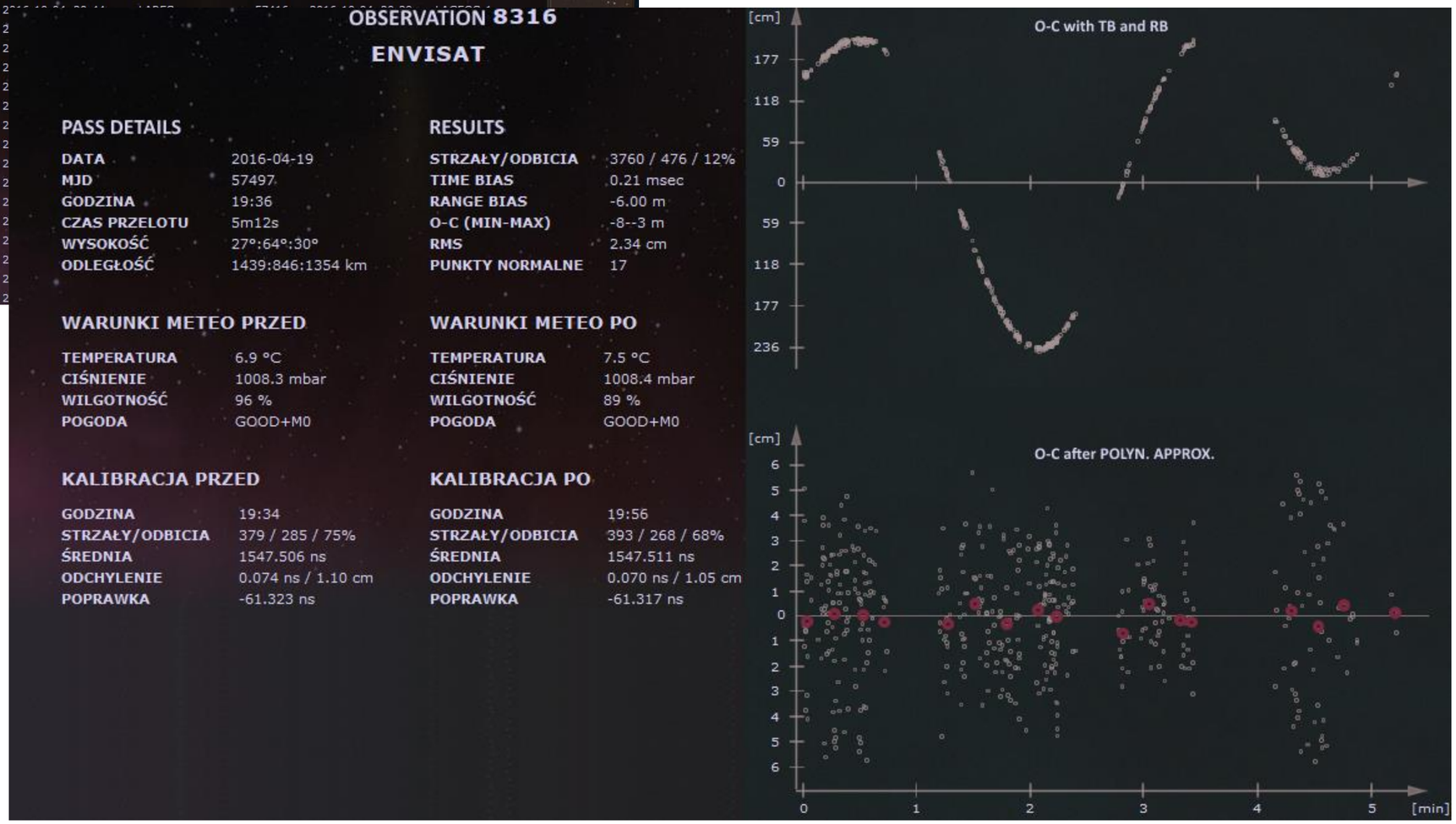
Tracking capabilities



Borowiec results available at

http://www.cbk.poznan.pl/stacja_laserowa/lista_obserwacji_2016.php





Safety and protection – SENTINEL-3A

March 30, 2016

International Laser Ranging Service

Central Bureau
International Laser Ranging Service
NASA Goddard Space Flight Center
Code 690
Greenbelt, MD 20771
USA

Tel: 301-614-6542
Fax: 301-614-6015
Internet: *ilrs-cb@lists.nasa.gov*
http://ilrs.gsfc.nasa.gov

SLR STATION AGREEMENT FOR LASER RANGING TO SENTINEL-3A

Station: **Borowiec, Poland**
Station No./Code: **7811/BORL**

We agree to support the SLR tracking of the Sentinel-3A. We understand that the campaign will start shortly and that the mission will provide predictions in a secure manner to be identified by the ILRS Central Bureau.

We understand that the mission payload is optically vulnerable and that the operating parameters of our station should be:

Wavelength (nm): **532**
Pulse Repetition Rate (Hz): **10**
Ranging System Output energy (mJ): **50 mJ**
Beam Divergence (arcsec FWHM): **30**

We agree that our station will operate with these parameters; we will cease tracking and inform the ILRS Central Bureau immediately if the flowing happens:

1. Output energy exceeds that above value;
2. Beam divergence is less than the above value;
3. Laser output wavelength or pulse repetition is changed

Since stations are approved individually, we agree not to share the predictions with anyone other than those who need them for the operation of the **Borowiec, Poland** station.

DYREKTOR CBK PAN

Signed: Stanisławska

Printed Name: *prof. dr hab. Iwona Stanisławska*

Position: Director

Organization: Space Research Centre of the Polish Academy of Sciences

This signed agreement should be returned to the ILRS Central Bureau c/o Carey Noll (carey.noll@nasa.gov).

Thank you for your support,

Michael R Pearlman

Dr. Michael R. Pearlman
Director, ILRS Central Bureau
Harvard-Smithsonian Center for Astrophysics
Cambridge MA 02138
USA

SENTINEL-3A

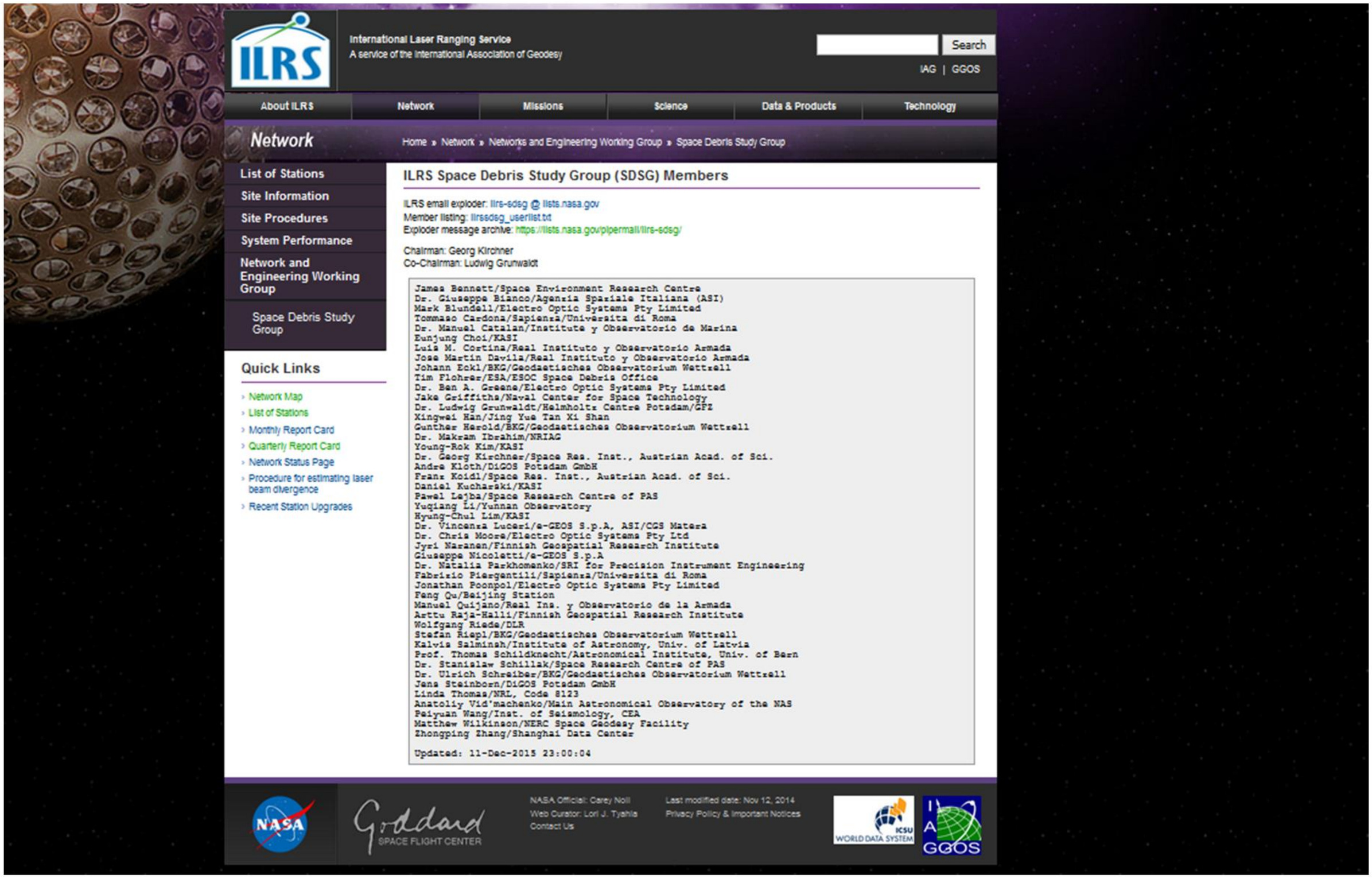
Current passes (October 4, 2016):

Number of passes: 44

Single shots (accepted): 38549

AVG RMS: 2.64 cm

Space Debris Study Group (SDSG)

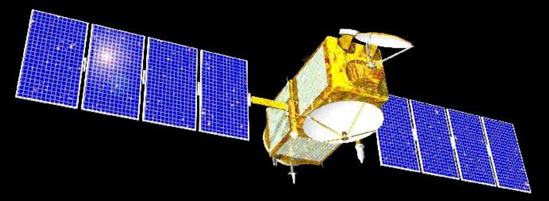


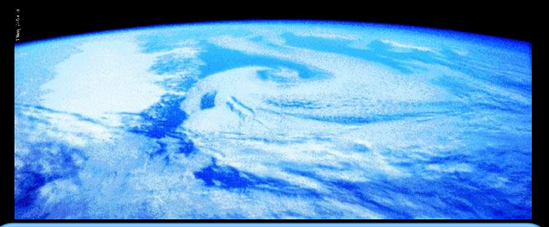
SRC Borowiec

Space Debris Tracking

Space debris – research, safety and protection

ENVISAT, 800 km

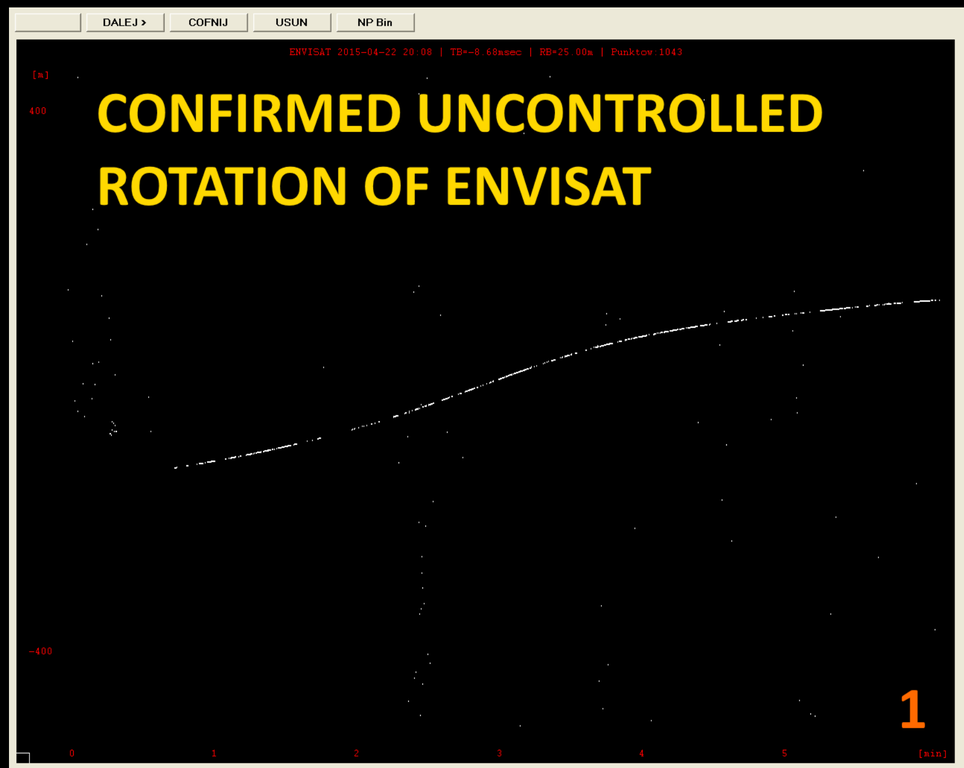


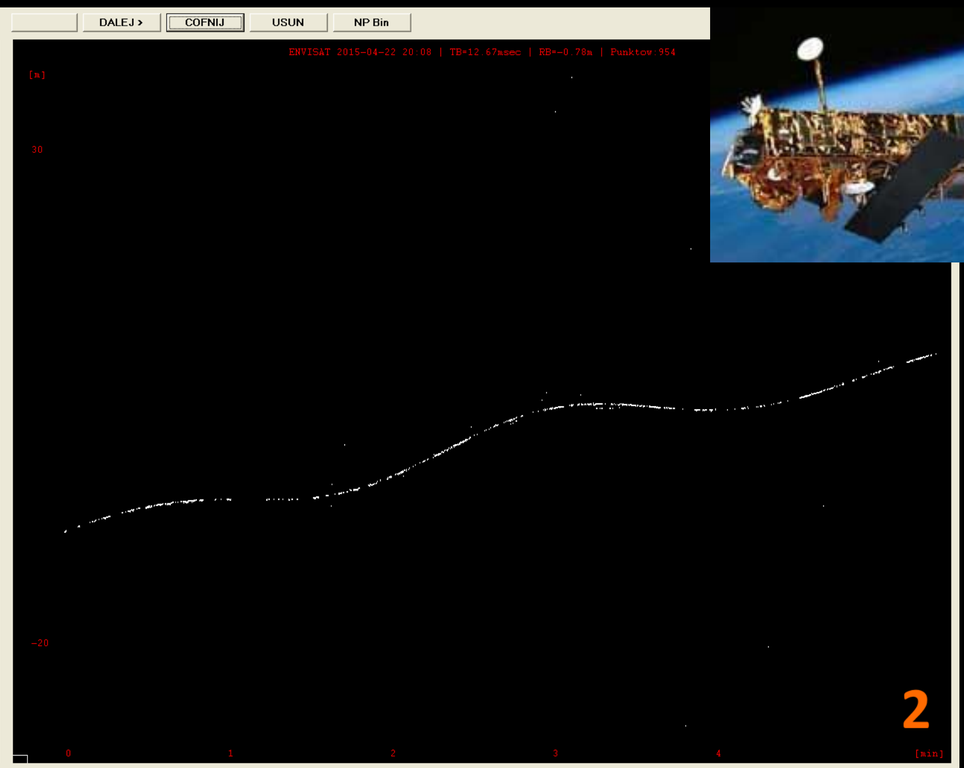


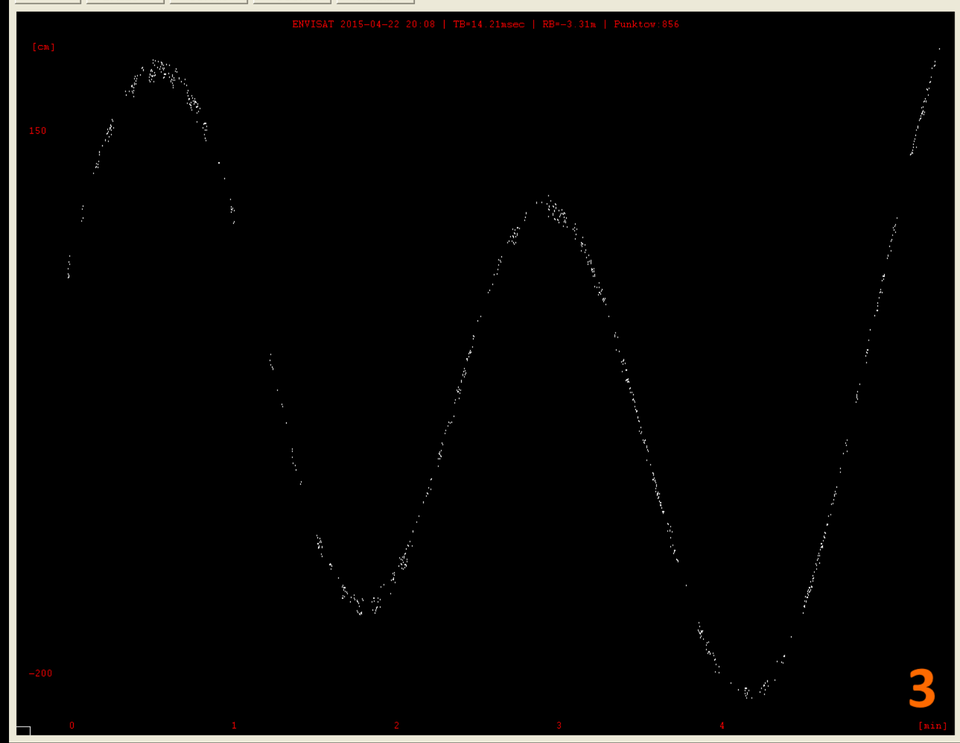
JASON-1, 1300 km

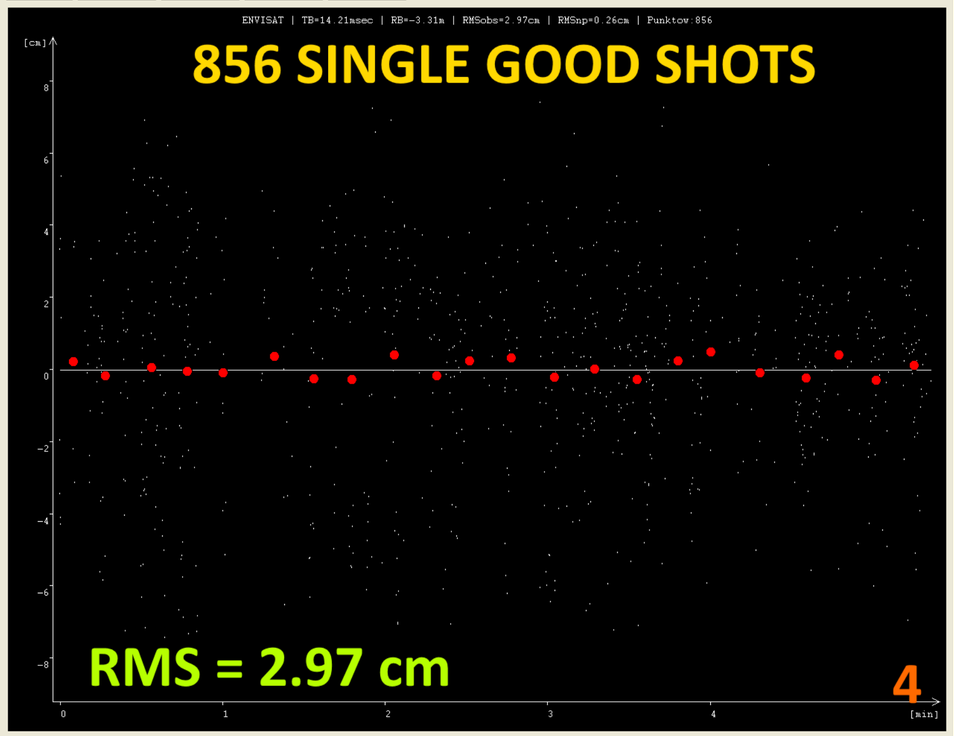
TOPEX/Poseidon, 1300 km

Space debris – ENVISAT

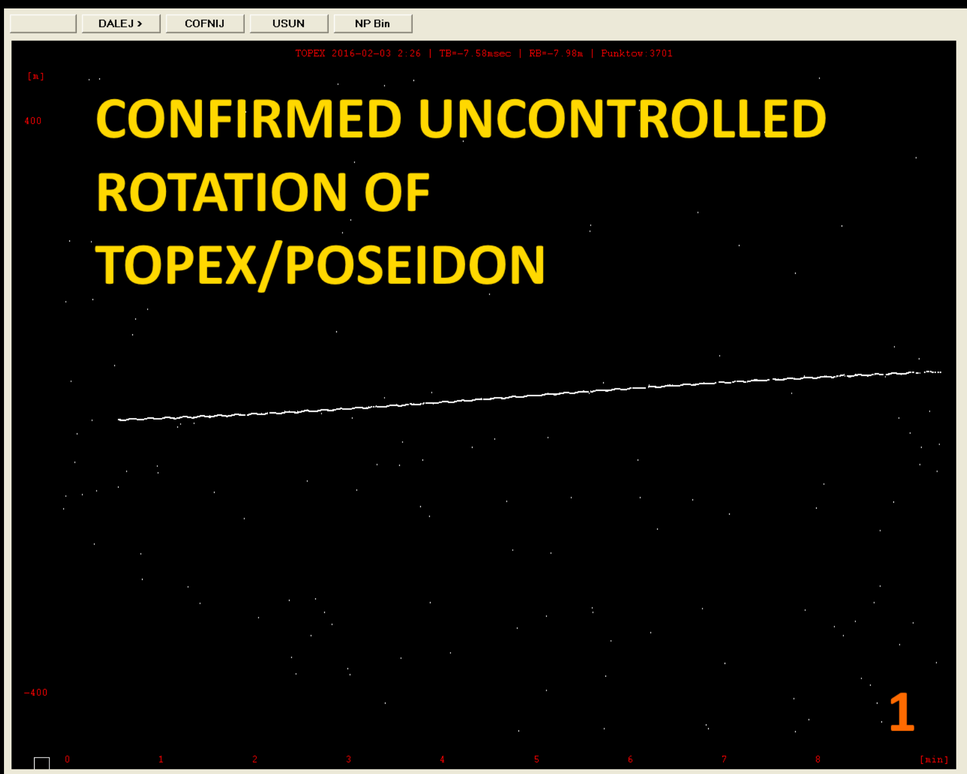


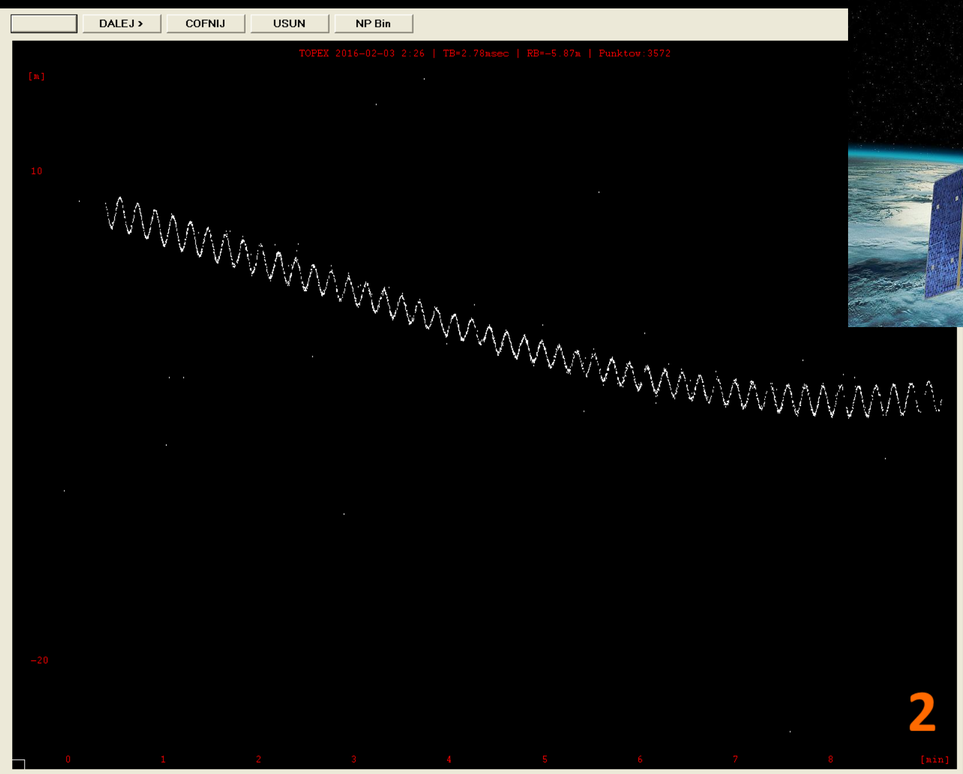


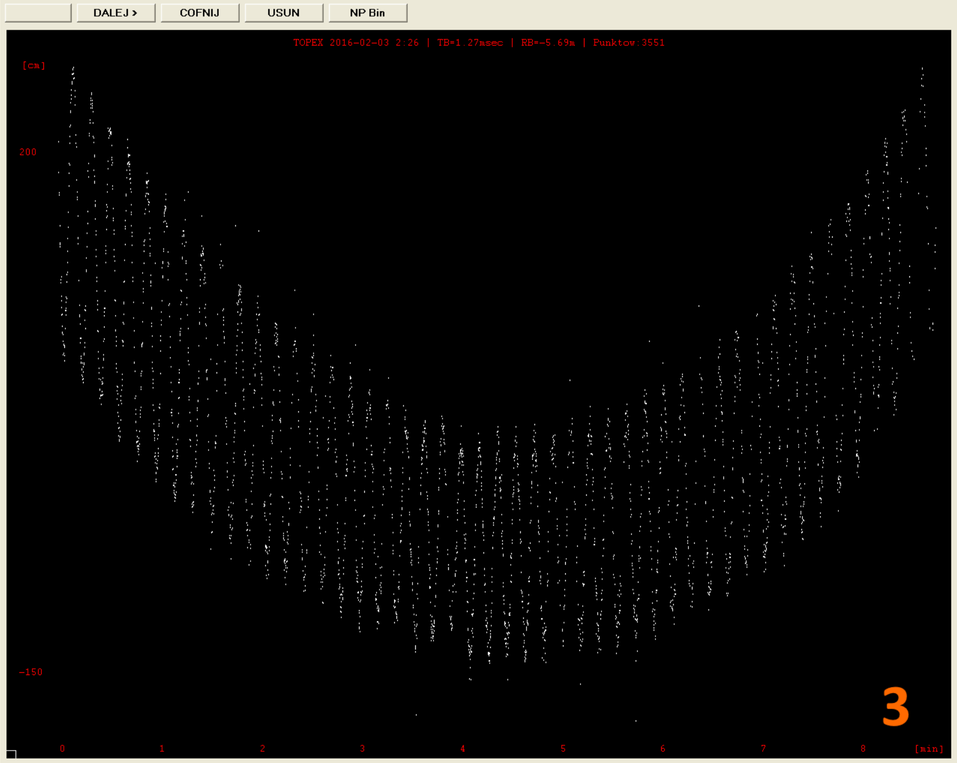


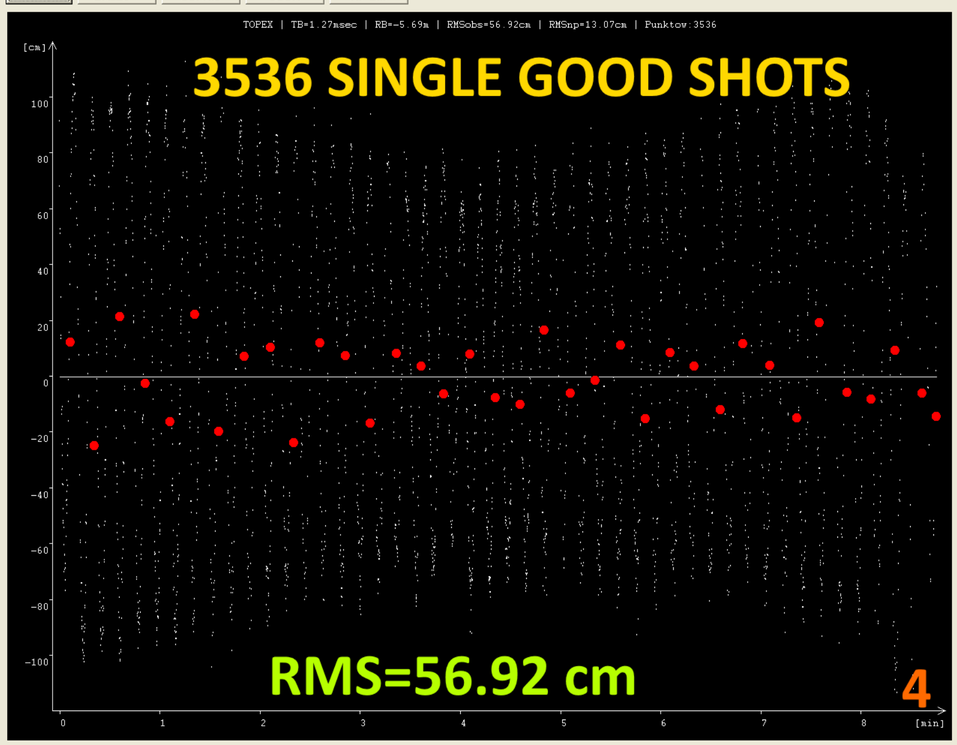


Space debris – TOPEX/POSEIDON







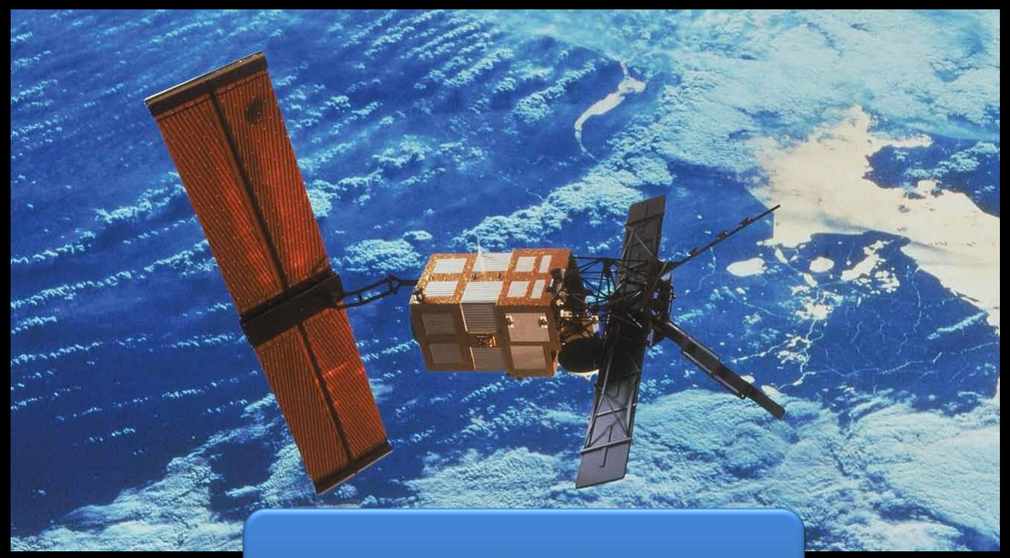


Space Debris Tracking

New Campaigns

SRC Borowiec space debris campaigns

ERS-2



ERS-1

OICETS

ADEOS-2

Space Debris Tracking

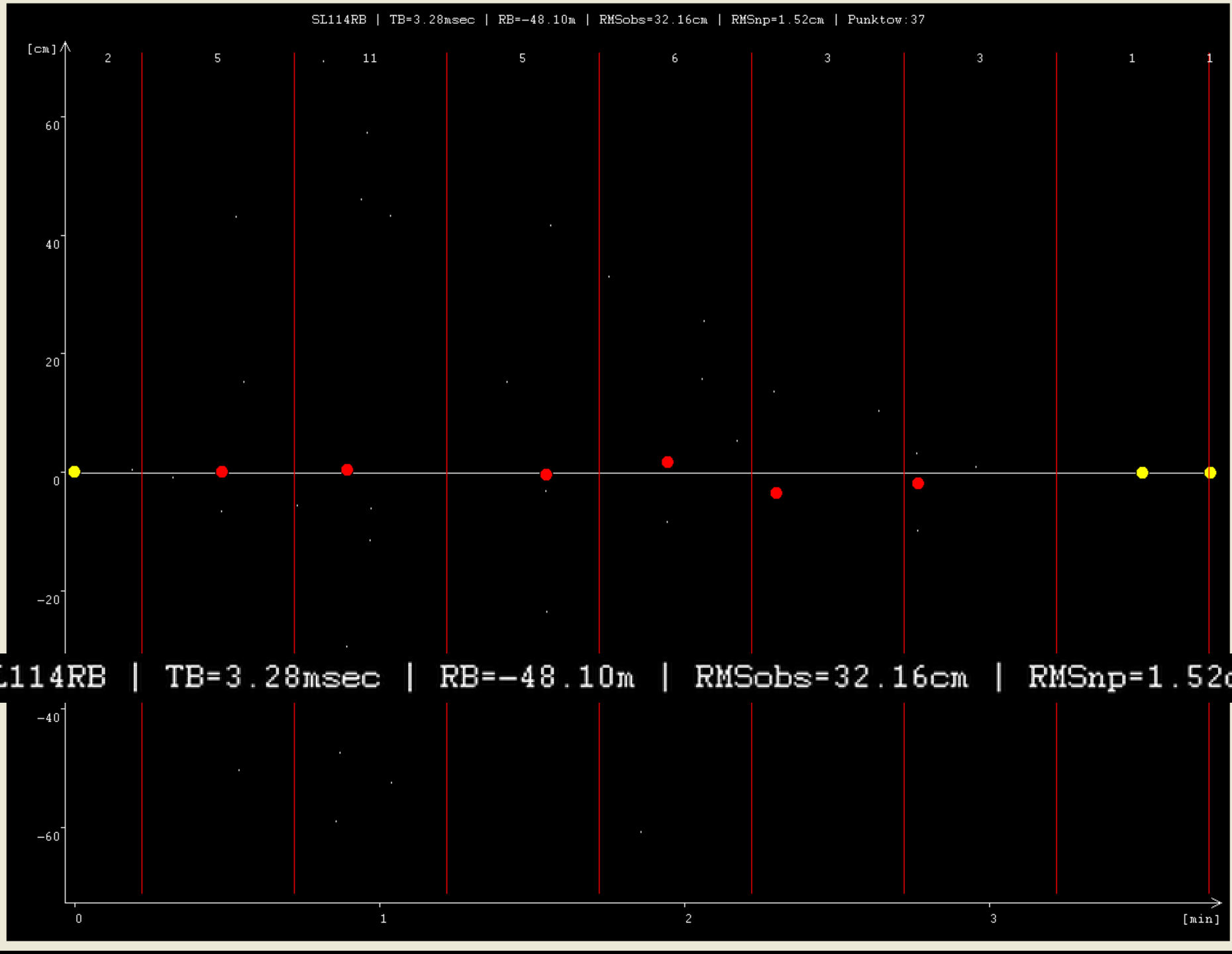
(*rocket bodies*)

SL14RB (17912)

10.08.2016, 01:10:50

< WSTECZ | DALEJ > | COFNIJ | USUN | NP Bin

SL114RB | TB=3.28msec | RB=-48.10m | RMSobs=32.16cm | RMSnp=1.52cm | Punktow:37

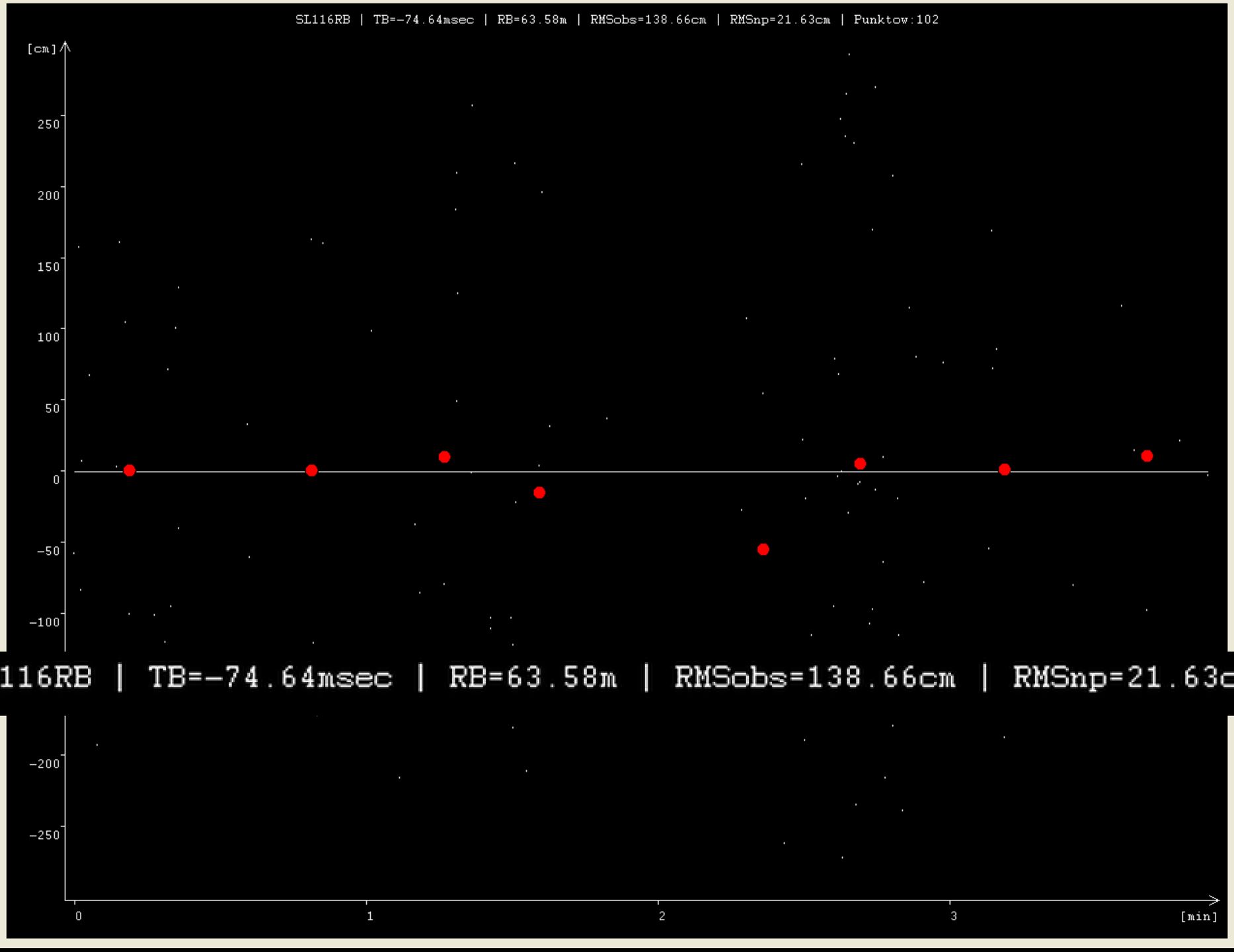


SL114RB | TB=3.28msec | RB=-48.10m | RMSobs=32.16cm | RMSnp=1.52cm | Punktow:37

SL16RB (23088)

15.08.2016, 00:57:30

< WSTECZ | DALEJ > | COFNIJ | USUN | NP Bin



SL116RB | TB=-74.64msec | RB=63.58m | RMSobs=138.66cm | RMSnp=21.63cm | Punktow:102

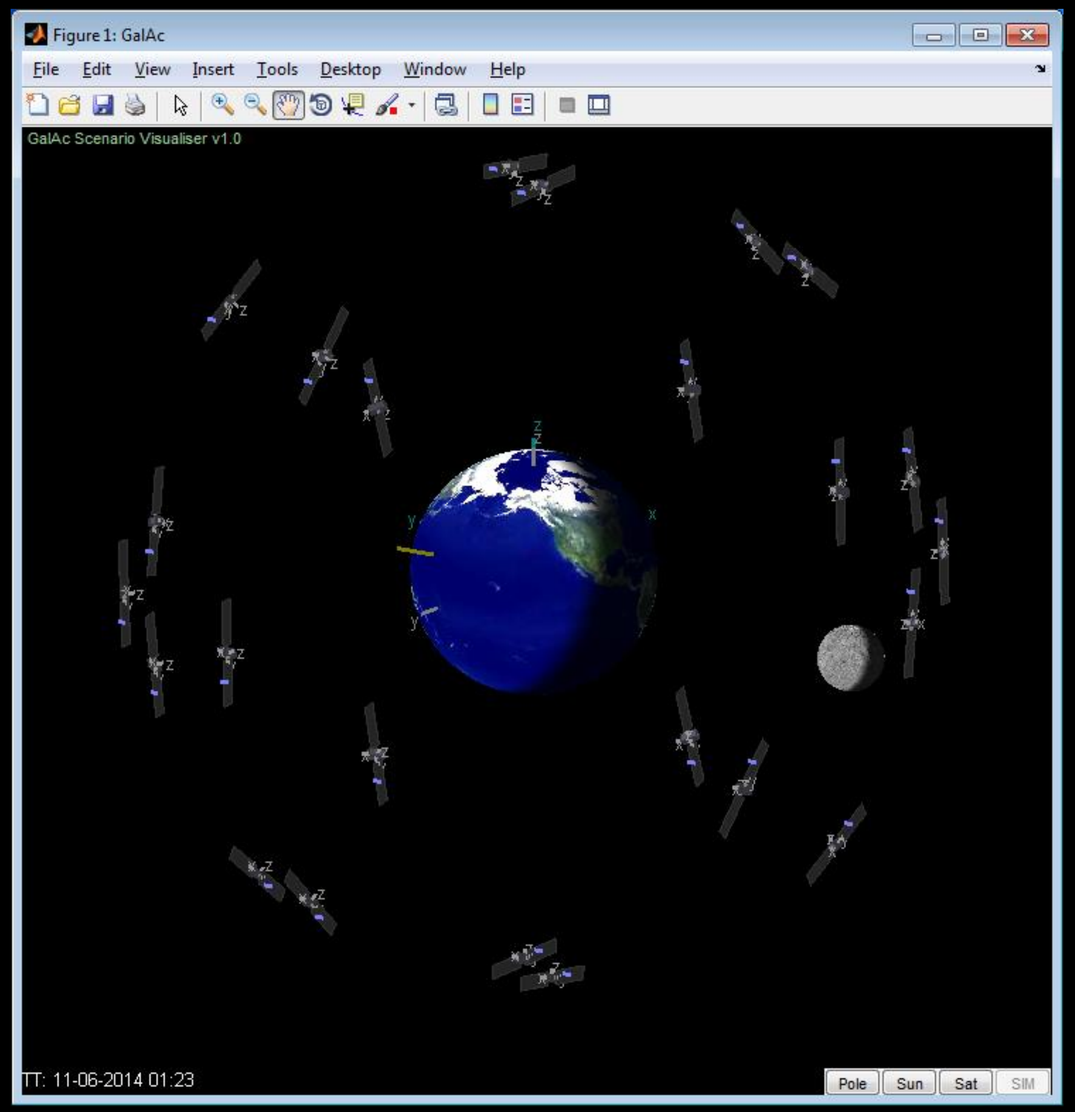
Own orbital

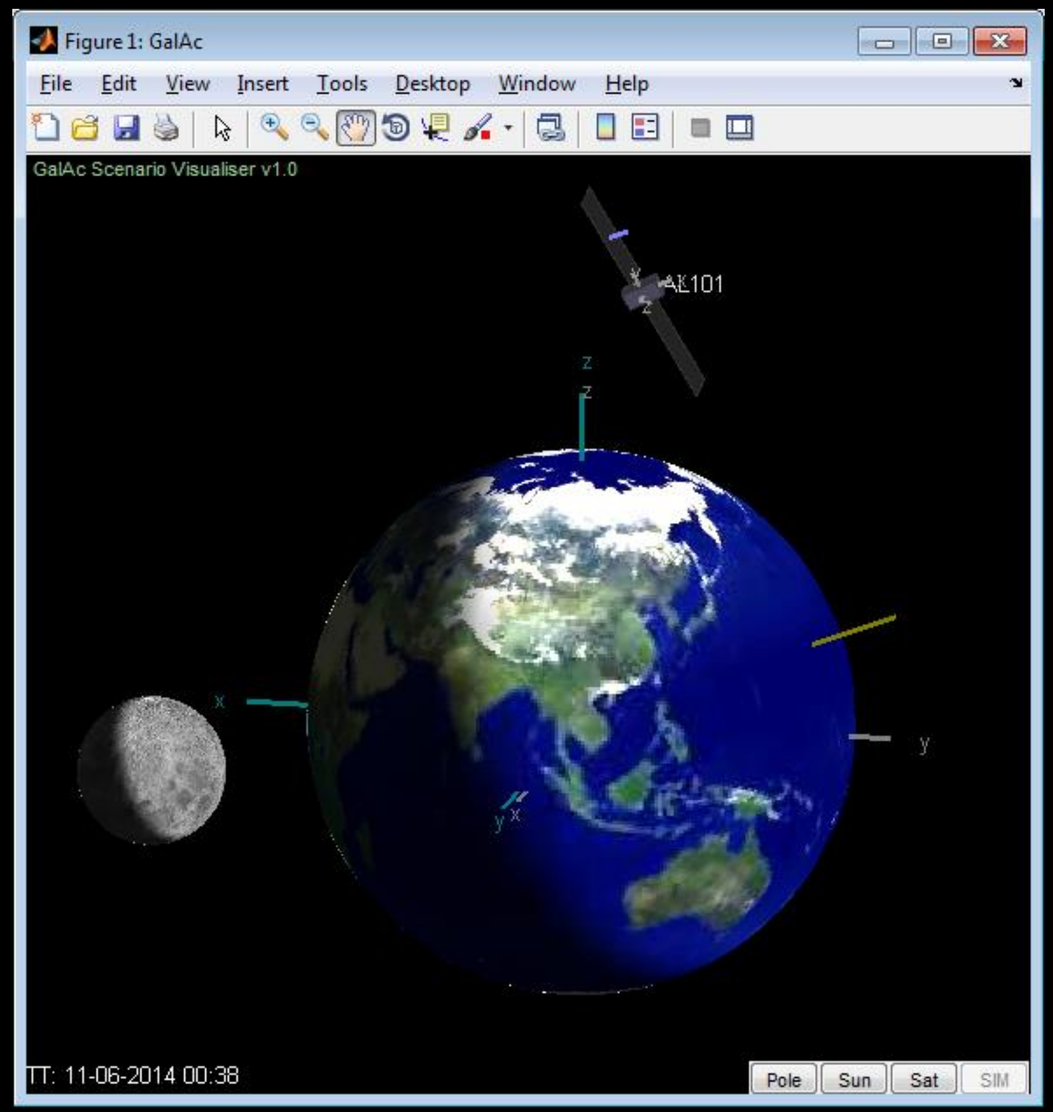
software development

GALAC – ESA contract

advanced orbital propagator

(compatible with IERS 2010 Conventions)



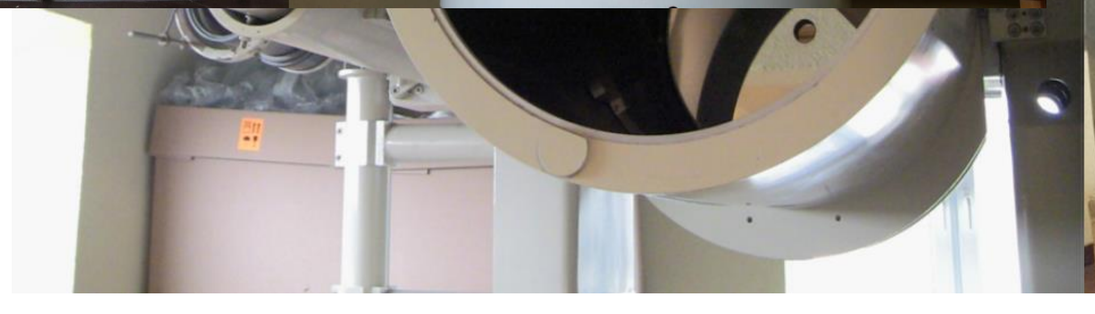


Near future…

Time Transfer – ACES/ELT

Atomic Clock Ensemble in Space (ACES)
European Laser Transfer (ELT)

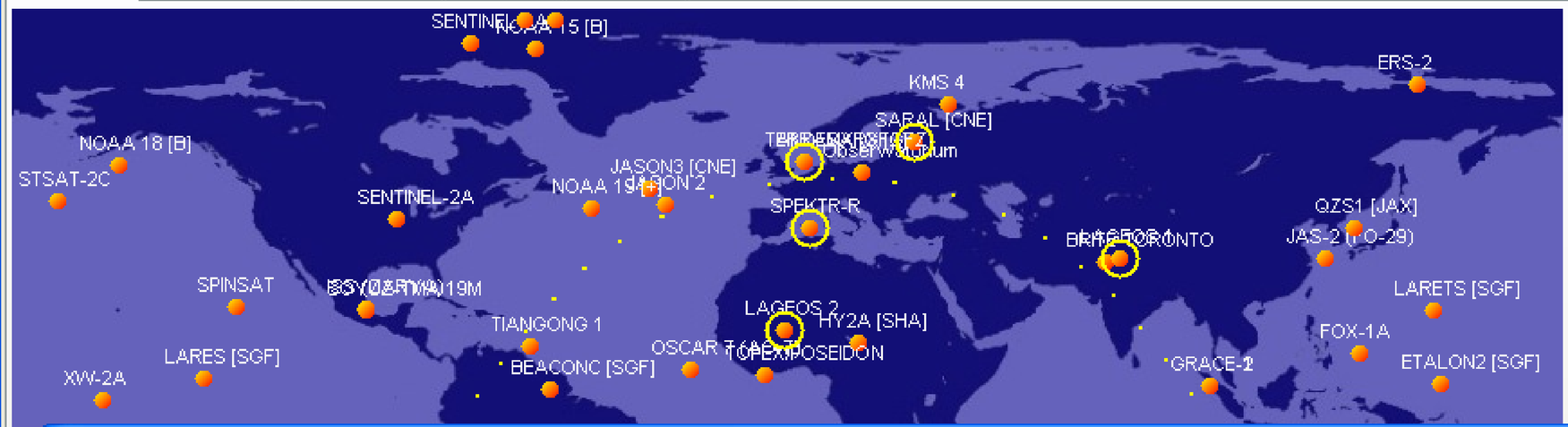
Second independent laser system
Space Surveillance and Tracking programme



Second independent laser system
new software

2016-04-19 17:02:21 UTC, dzień roku: 110 Do następnego przelotu: brak obserwowanych satelitów

Wizualizacja | Import TLE, CPF | Dane orbitalne | Planowanie | Obserwacje | Ustawienia



- AJISAI (EGS)
- BEACONC [SGF]
- BRITE-AUSTRIA
- BRITE-PL
- BRITE-PL 2
- BRITE-TORONTO
- CRYOSAT 2
- ENVISAT
- ERS-2
- ETALON1 [SGF]
- ETALON2 [SGF]
- FOX-1A
- FUNCUBE-1 (AO-73)
- GRACE-1
- GRACE-2

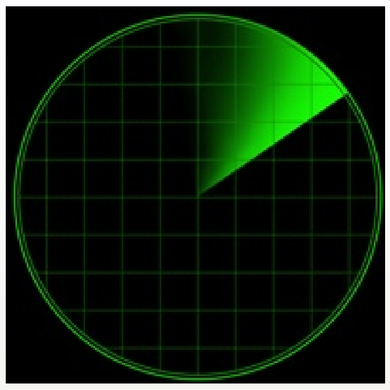
SAT | Radio | Inne

```
AJISAI (EGS)

Czas [UT]:  17:02:21
Czas [LT]:  19:02:21

Długość:    105,29 E
Szerokość:  36,55 S
Azymut:     268,0634°
Elewacja:   -66,3055°▲

Odległość:  13278▼ km
Zbliżanie:  -2,197 km/s

Obieg:      1h 55m 43s
Apogeum:    1497 km
```

2016-04-19 16:03:29 UTC, dzień roku: 110 Do następnego przelotu: 22 minut - Satelita: XW-2A_20162519_162523.txt

Wizualizacja | Import TLE, CPF | Dane orbitalne | Planowanie | Obserwacje | Ustawienia

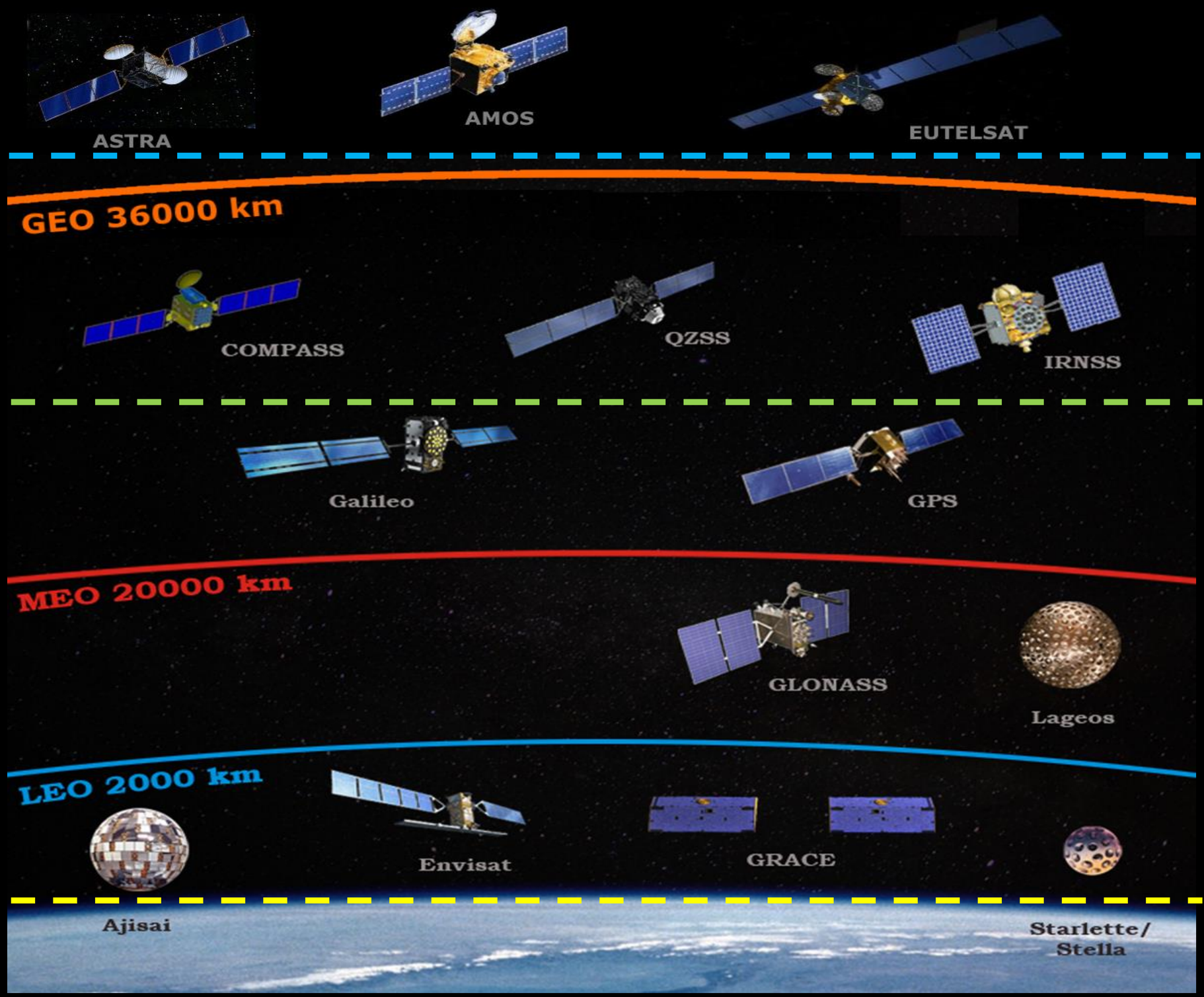
	Obserwacja	Predykcja	Efemeryda	Efemeryda (dni)	NC-Code	Satelita	Początek przelotu (UTC)	Koniec przelotu (UTC)	Czas przelotu	Elewacja min.	El m
☐	1181	17059	6382	0	XW-2A_20162519_162523.txt	XW-2A	2016-04-19 16:25:23	2016-04-19 16:32:12	00:06:49	10	6
☐	1182	17045	6388	0	SENTINEL-1A_20164719_16471...	SENTINEL-1A	2016-04-19 16:47:18	2016-04-19 16:56:12	00:08:54	10	3
☐	1183	17060	6382	0	XW-2A_20160119_180103.txt	XW-2A	2016-04-19 18:01:03	2016-04-19 18:03:11	00:02:08	10	1
☐	1184	17050	6370	1	SENTINEL-2A_20162019_18203...	SENTINEL-2A	2016-04-19 18:20:32	2016-04-19 18:23:08	00:02:36	10	1
☐	1185	17055	6389	0	SENTINEL-3A_20160119_19011...	SENTINEL-3A	2016-04-19 19:01:18	2016-04-19 19:10:42	00:09:24	10	3
☐	1186	17051	6370	1	SENTINEL-2A_20165519_19551...	SENTINEL-2A	2016-04-19 19:55:10	2016-04-19 20:05:10	00:10:00	10	4
☐	1187	17056	6389	0	SENTINEL-3A_20164019_20403...	SENTINEL-3A	2016-04-19 20:40:34	2016-04-19 20:50:42	00:10:08	10	4
☐	1188	17052	6370	1	SENTINEL-2A_20163519_21351...	SENTINEL-2A	2016-04-19 21:35:18	2016-04-19 21:44:24	00:09:06	10	2
☐	1189	17046	6388	0	SENTINEL-1A_20163920_04395...	SENTINEL-1A	2016-04-20 04:39:58	2016-04-20 04:48:40	00:08:42	10	3
☐	1190	17061	6382	0	XW-2A_20161520_051554.txt	XW-2A	2016-04-20 05:15:54	2016-04-20 05:22:21	00:06:27	10	3
☐	1191	17047	6388	0	SENTINEL-1A_20161720_06173...	SENTINEL-1A	2016-04-20 06:17:38	2016-04-20 06:26:15	00:08:37	10	3
☐	1192	17062	6382	0		XW-2A	2016-04-20 06:49:07	2016-04-20 06:54:41	00:05:34	10	2
☐	1193	17057	6389	0	SENTINEL-3A_20164920_08491...	SENTINEL-3A	2016-04-20 08:49:15	2016-04-20 08:59:23	00:10:08	10	4
☐	1194	17053	6370	1	SENTINEL-2A_20164120_09411...	SENTINEL-2A	2016-04-20 09:41:12	2016-04-20 09:51:36	00:10:24	10	6
☐	1195	17058	6389	0	SENTINEL-3A_20162920_10291...	SENTINEL-3A	2016-04-20 10:29:15	2016-04-20 10:38:39	00:09:24	10	3



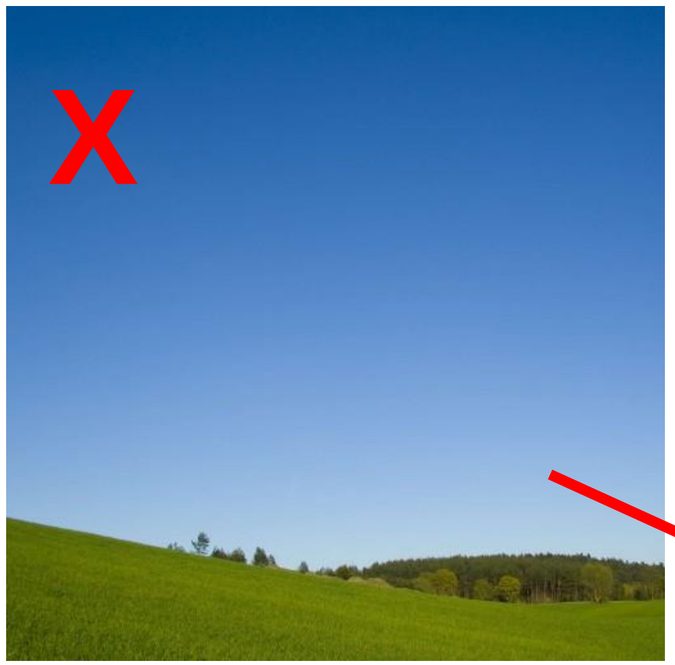
- Otwórz/ zamknij dach
- Załącz / wyłącz napędy
- Montaż na spoczynkową
- Montaż na polarną
- Montaż na TARGET
- Kalibracja na żądanie

label42

Tracking capabilities

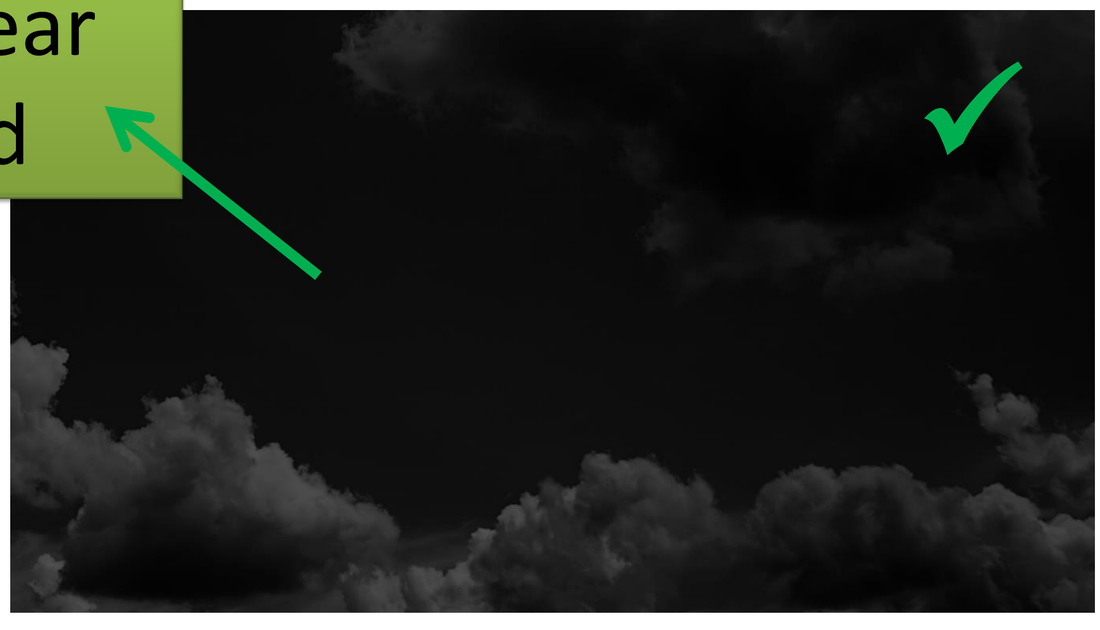


Day observations



to reach
3500
passes/year
treshold

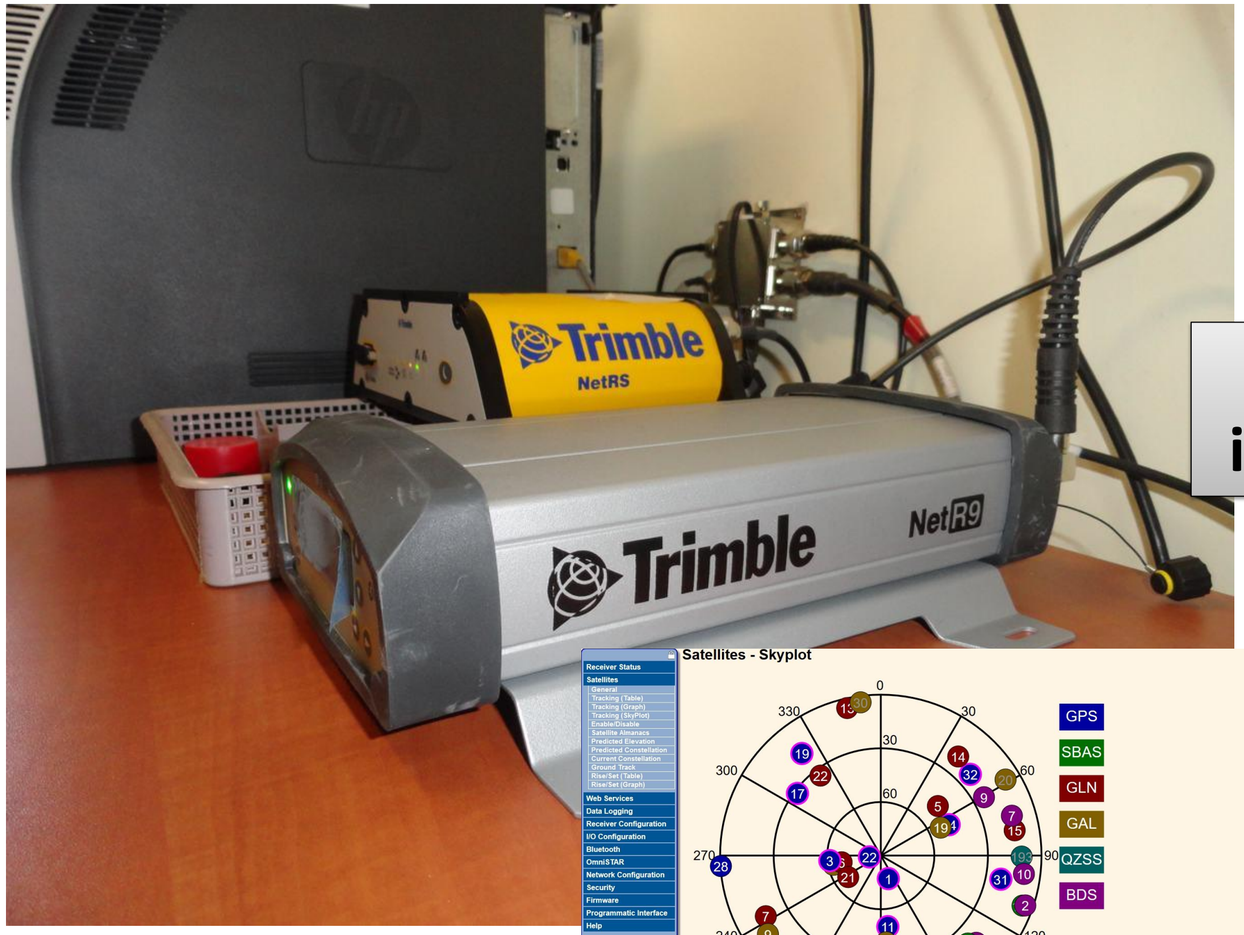
Efficiency ≈ 33 %



IGS BOR1 point modernization

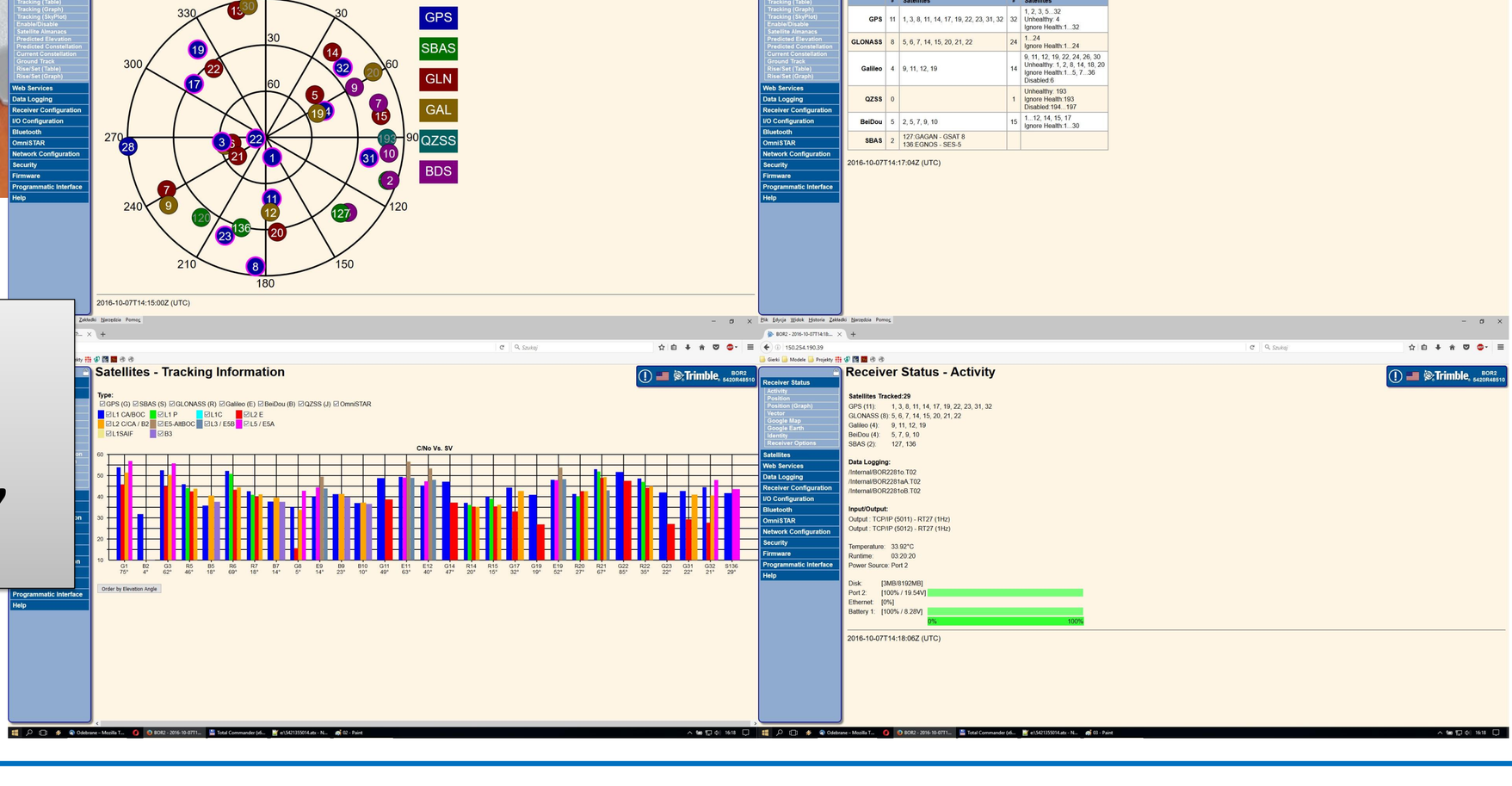
IGS BOR1 – SLR BORL

New GNSS receiver – IGS BOR1



GNSS receiver installed on February 5, 2015

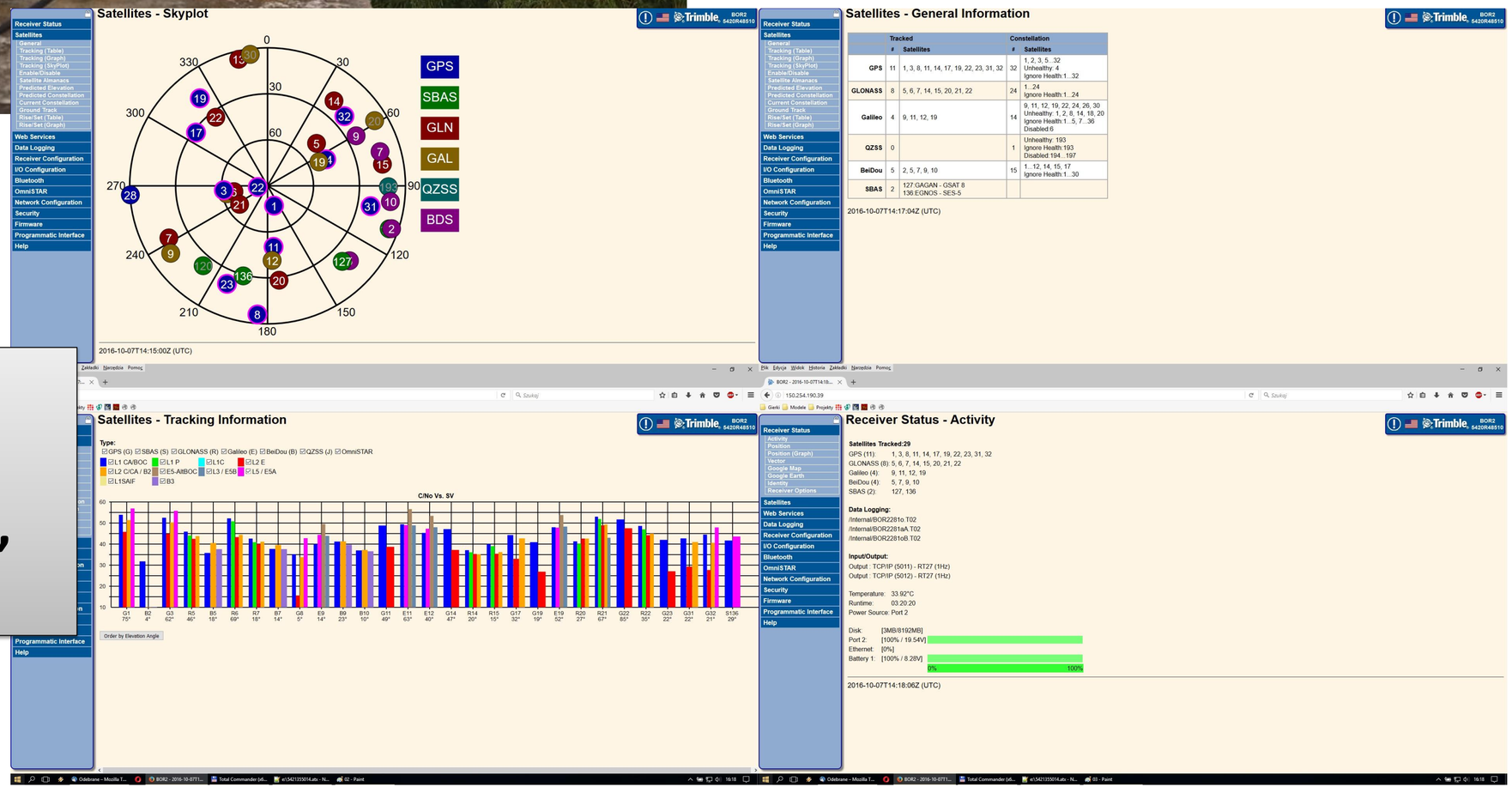
Sample screens GPS, GLONASS, GALILEO, BEIDOU, SBAS



New GNSS antenna – IGS BOR1

GNSS antenna installed on October 5, 2016

Sample screens GPS, GLONASS, GALILEO, BEIDOU, SBAS



SUMMARY

- high quality observations of satellites (results confirmed by AC's)
- AVG RMS from 1.19 cm to 5.54 cm (ILRS satellites)
- second SLR system under construction
- space debris observations (LEO regime)
- ACES/ELT experiment is underway
- observations of GNSS satellites
- KHz direction
- Better contribution to the GGOS (IGS BOR1, SLR BORL)